IRCSEM

YAGI LAB.

[Electrochemical Materials and Processes]

Integrated Research Center for Sustainable Energy and Materials

Energy Storage Materials Engineering

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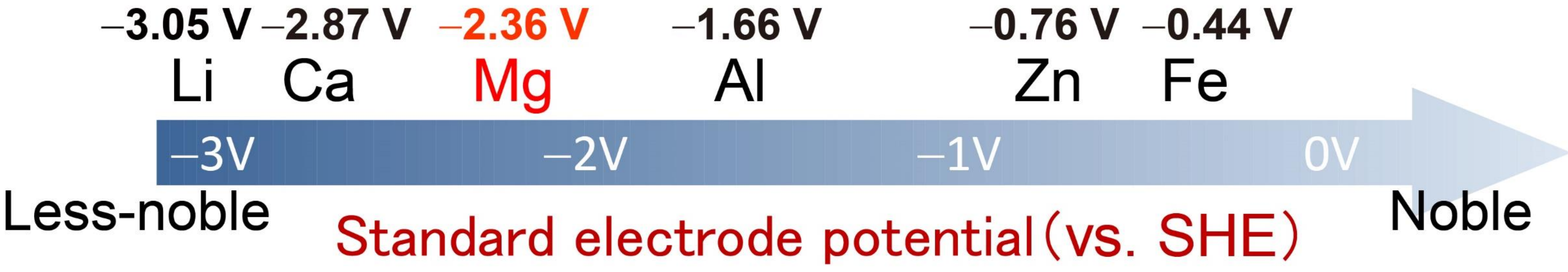
Electrochemical Reaction

Electrochemical reactions convert chemical energy to electrical energy and vice versa. Rechargeable batteries store electrical energy as chemical energy, and convert the chemical energy to electrical energy when necessary. For example, electrochemical reactions generate hydrogen and oxygen through water decomposition, and allow for metal and oxide deposition. In our laboratory, we investigate new rechargeable batteries using multivalent cations as carrier ions (specifically, magnesium rechargeable batteries) and electrochemical catalysts for efficient and fast electrochemical reactions.

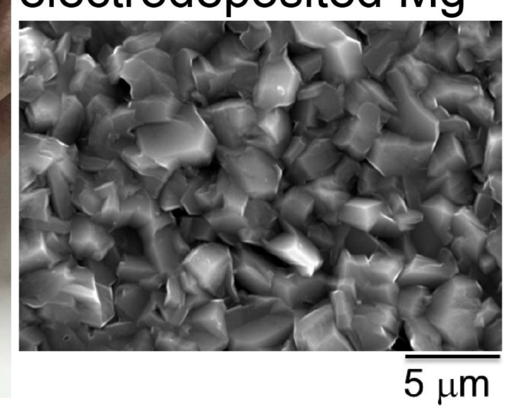
Magnesium Rechargeable Battery



Standard electrode potential. Metals with large negative standard electrode potentials tend to release electrons to form cations. By using such a metal as a negative electrode active material, a large electromotive force can be achieved. Mg possesses two valence electrons and has the lowest standard electrode potential (ca. -2.36 V vs. SHE) among the air-stable metals. Thus, we investigate Mg batteries as potential rechargeable batteries with high electromotive force, high energy density, and ease of handling.

Prototype of Mg battery

Flat surface of electrodeposited Mg

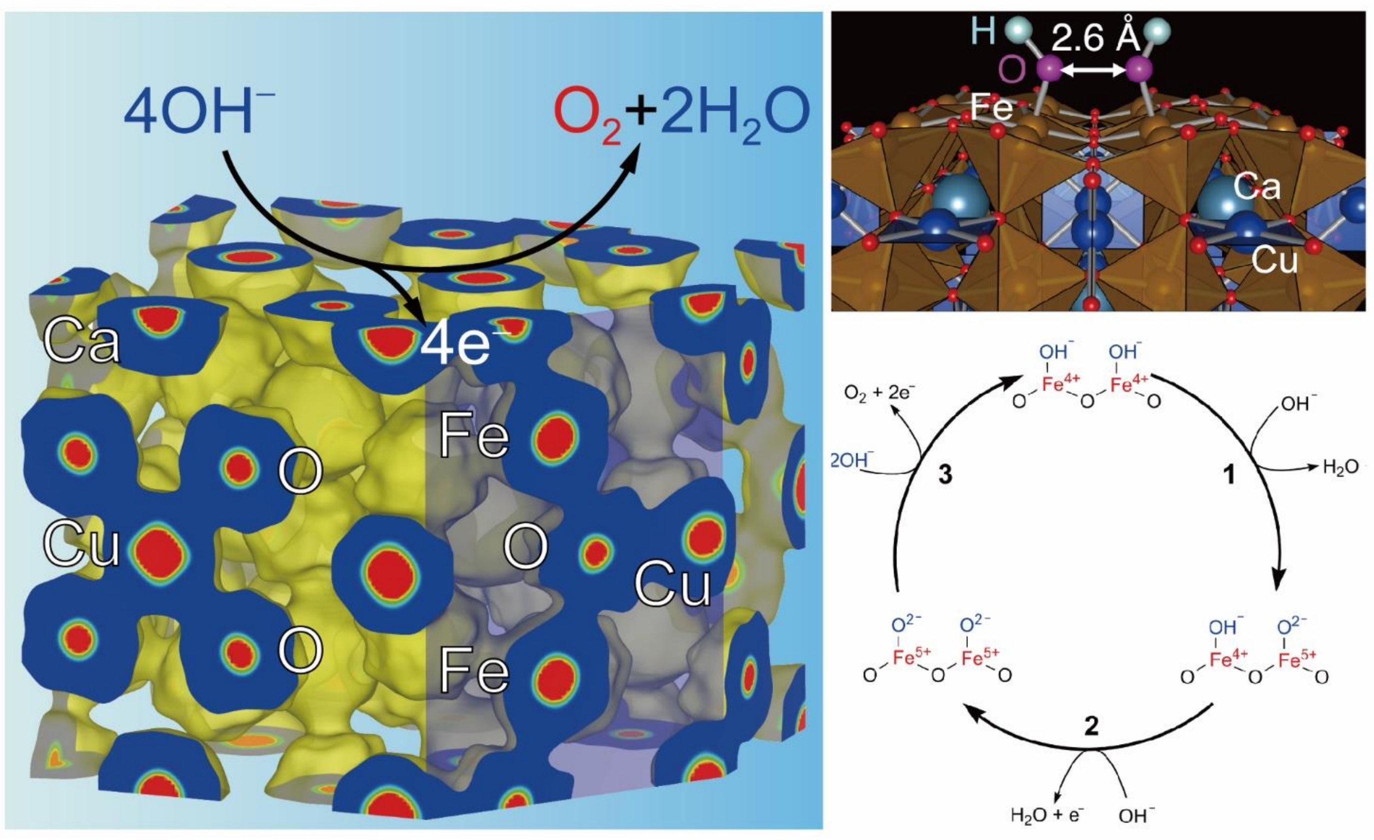


	Potential (V vs. SHE)	Capacity (mAh/g)	Capacity (mAh/cc)
Mg	−2.36	2200	3830
LiC_6	−2.8	372	841
Li	−3.05	3860	2070

Electrical capacity of Li, graphite (LiC_6), Mg. Mg metal can be used as an active material because it hardly forms dendrites, while Li metal cannot be used because of dendritic growth, which causes detachment and short-circuiting.

Electrochemical Catalyst

Fuel cells and metal-air rechargeable batteries have been extensively studied as electrochemical devices, using oxygen gas in the air as a positive electrode active material. Excellent electrochemical catalysts are required to enhance the reaction efficiency and electromotive force of these devices. In our laboratory, we explore the universal descriptors of catalytic activity in terms of the structure, composition, and electronic states of the catalysts, with the help of researchers in solid-state chemistry from within and outside the university. We also prepare prototypes of the electrochemical devices and evaluate them. The electrochemical catalysts investigated can also be used for water electrolysis to produce hydrogen and oxygen, and for an insoluble anode in wet smelting, thus reducing the energy and expense in many processes.



Structure of the electrochemical catalyst $CaCu_3Fe_4O_{12}$ and proposed pathway for oxygen evolution reaction on its surface.